Biological Classification

- **Taxonomy**: naming & classifying organisms
- **Systematics**: studying relationships among taxonomic groups

Taxonomy & Linnaean Hierarchy

- Levels called ***taxa*** (sing., ***taxon***: "classification")
  - The more similar two organisms are, the more levels they have in common

a) **Kingdom**
b) **Phylum (Division)***
c) **Class**
d) **Order**
e) **Family***
f) **Genus**
g) **Species**

*not in the original Linnaean hierarchy

"King Philip Came Over For Good Soup"
"Kings Play Chess On Fine Green Sand"
Carl Linné, 1737

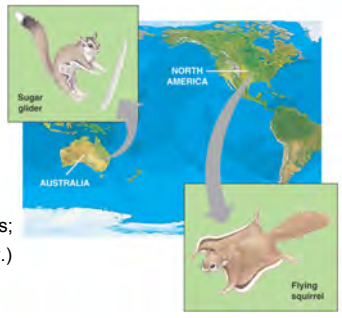
IV. Phylogenetic Systems

- Classified based on *presumed* common ancestry
- Levels in common suggests a more recent divergence from a common ancestor.
- But since we don't actually know the ancestry above the level of genus or maybe family, dependent upon degrees of similarity.
  - Comparative morphology & anatomy
  - Comparative embryology
  - Comparative biochemistry — proteins & DNA
- Much disagreement may be debated regarding which similarities and which differences are most phylogenetically significant!

Problem: Divergence vs. Convergence — Homology vs. Analogy

Similarity due to convergence is **analogy**.

(Similar adaptations to similar environments; not shared ancestry.)



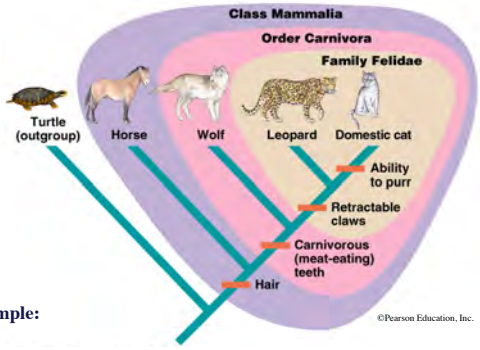
Cladistics

- **Clade** ("branch") — replace traditional taxon
  - Groups of organisms presumed to be derived from a common ancestor are organized by **bifurcating** (two-way splitting) of a branch
  - Each bifurcation is based upon the acquisition of a new, unique character (**apomorphy**).
- **Maximum parsimony**: the branch pattern that can be created with the fewest required steps is most likely the most correct.

Cladistics

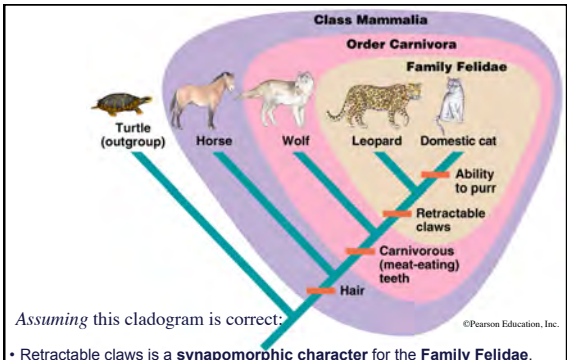
More vocabulary:

- A true **clade** must be **monophyletic**
  - must include an ancestor and all of the known descendants of that ancestor.
    - A grouping that only includes an ancestor and some of its descendants is **paraphyletic**.
    - A grouping that includes organisms from different ancestries is **polyphyletic**.
- Derived **apomorphic** characters shared by members of a clade are **synapomorphic**.
- Ancestral characteristics inherited prior to the branching of a clade are **plesiomorphic**.



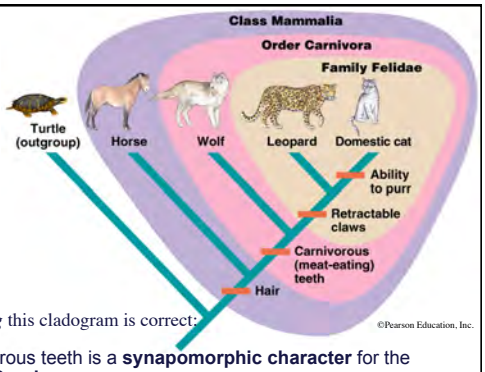
For example:

Hair, Carnivorous teeth, Retractable claws, & Ability to purr are all **apomorphic characters** in the *presumed* ancestry of the domestic cat



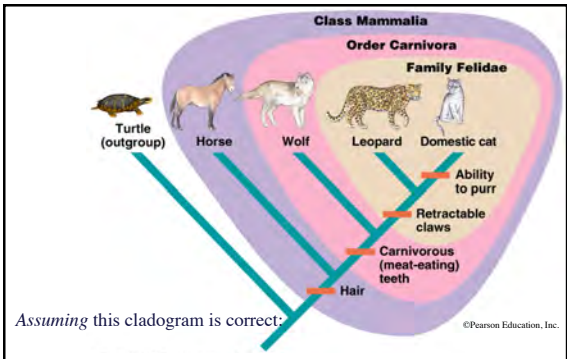
Assuming this cladogram is correct:

- Retractable claws is a **synapomorphic character** for the **Family Felidae**.
- Hair & Carnivorous teeth are **plesiomorphic characters** for the **Family Felidae**.



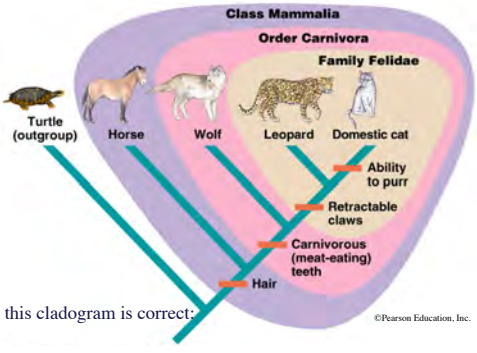
Assuming this cladogram is correct:

- Carnivorous teeth is a **synapomorphic character** for the **Order Carnivora**.
- Hair is a **plesiomorphic character** for the **Order Carnivora**.



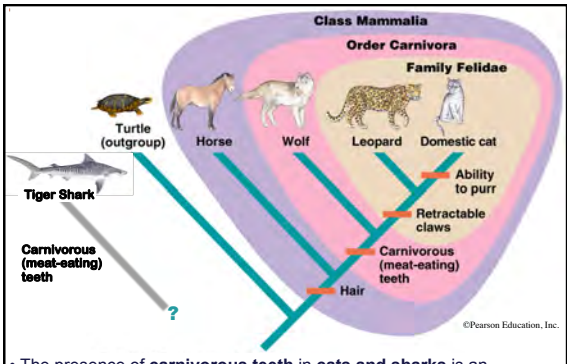
Assuming this cladogram is correct:

- Hair is a **synapomorphic character (synapomorphy)** for the **Class Mammalia**.



Assuming this cladogram is correct:

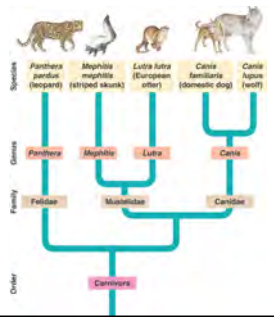
- The presence of **carnivorous teeth** in **cats and wolves** is a **homology**.



- The presence of **carnivorous teeth** in **cats and sharks** is an **analogy.**
  - (in cladistics, also called a **homoplasy**).

Cladogram vs. Taxa

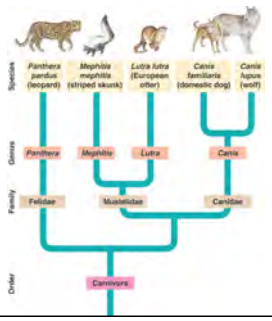
Monophyletic clades



Cladogram vs. Taxa

Paraphyletic grouping

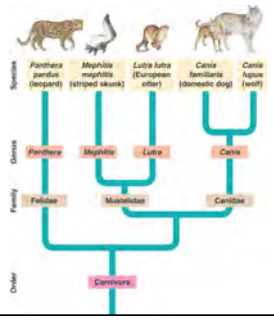
Not a true clade!



Cladogram vs. Taxa

Polyphyletic grouping

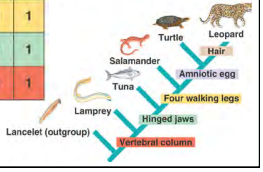
Not a true clade!
Not phylogenetic!



Building Cladograms

Assemble a **table of character states**

	Lancelet (outgroup)	Lamprey	Tuna	Salamander	Turtle	Leopard
Hair	0	0	0	0	0	1
Amniotic (shelled) egg	0	0	0	0	1	1
Four walking legs	0	0	0	1	1	1
Hinged jaws	0	0	1	1	1	1
Vertebral column (backbone)	0	1	1	1	1	1



Building Cladograms

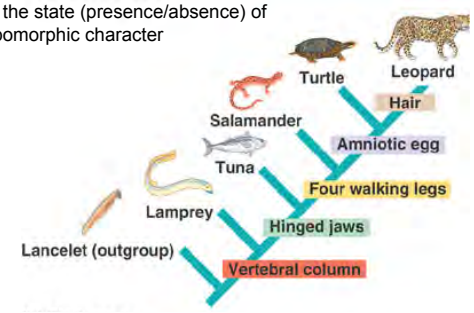
Major assumptions:

1. The group of organisms is monophyletic
2. The **outgroup** (used for comparison) is closely related to, but separate from your group
3. You can tell which character states are homologous or analogous.

	Lancelet (outgroup)	Lamprey	Tuna	Salamander	Turtle	Leopard
Hair	0	0	0	0	0	1
Amniotic (shelled) egg	0	0	0	0	1	1
Four walking legs	0	0	0	1	1	1
Hinged jaws	0	0	1	1	1	1
Vertebral column (backbone)	0	1	1	1	1	1

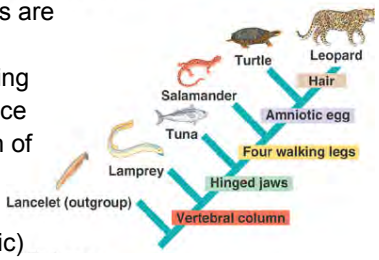
Building Cladograms

Each bifurcation of the branch is based upon the state (presence/absence) of an apomorphic character



Cladograms

Cladograms are made by hypothesizing the sequence of evolution of shared derived (apomorphic) characters

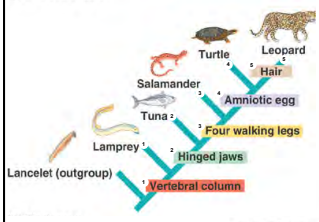


Building Cladograms

1. Arrange your ingroup species in order of similarity to the outgroup.
2. Arrange apomorphic characters in order of appearance in species most similar to the outgroup.

	Lancelet (outgroup)	Lamprey	Tuna	Salamander	Turtle	Leopard
5 Hair	0	0	0	0	0	1
4 Amniotic (shelled) egg	0	0	0	0	1	1
3 Four walking legs	0	0	0	1	1	1
2 Hinged jaws	0	0	1	1	1	1
1 Vertebral column (backbone)	0	1	1	1	1	1

Building Cladograms



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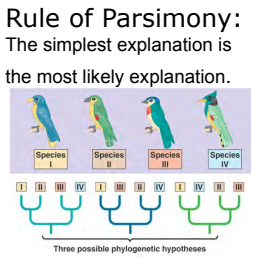
1 Vertebral column (backbone)	0	1	1	1	1	1

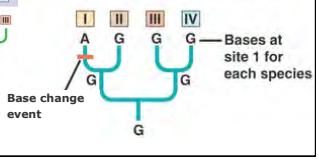
Cladograms

Rule of Parsimony:
The simplest explanation is the most likely explanation.



Sites in DNA sequence

Species	1	2	3	4	5	6	7
I	A	G	G	G	G	G	T
II	G	G	G	A	G	G	G
III	G	A	G	G	A	A	T
IV	G	G	A	G	A	A	G



Cladograms

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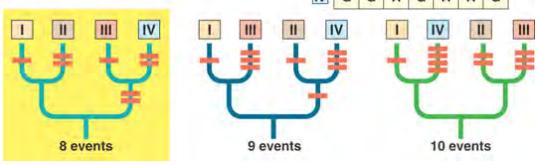

Cladograms

Rule of Parsimony:
The simplest explanation is the most likely explanation.

But not always!